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Some Like It Hot

Like it or not, the heat is a fact of life in the Sonoran Desert, the hottest desert in North America. Most forms of life resist the extreme temperatures—and extreme they are. A person stripped of clothing, water, and shade in the morning could be dead by evening.

How do desert plants and animals survive? Many become creatures of the night, as depicted in the accompanying foldout. The saguaro cactus develops an intricate, shallow root system that allows this desert giant to absorb and store up to 760 liters of water. The kangaroo rat recycles and retains water so that very little moisture is lost through urination. Birds ride warm currents of air to find relief at great heights. The spadefoot toad burrows deep into the ground for a period of estivation (a state akin to hibernation), while lizards migrate back and forth from sun to shade. Cicadas extract water from their blood and transport this water through large ducts to the surface of their body, where it evaporates.

Despite the heat, the Sonoran Desert is considered by many to be the most beautiful North American desert. With more than 2,500 species of plants, it is the most botanically diverse desert, providing abundant food sources for animals. Despite the torrid temperatures, the Sonoran is a magnet for the millions of people surrounding this region who are attracted by its rich natural resources and open spaces. Encompassing 312,000 square kilometers, the Sonoran Desert is spread across Mexico and the United States. It is one of the four North American deserts, along with the Great Basin, the Mojave, and the Chihuahuan. Much of this vast area receives less than 2.5 centimeters of rainfall each year, but its higher elevations, which exceed 2,100 meters, receive as much as 38 centimeters.

Vegetation in the westernmost third of the Sonoran—the lowest and driest part of the desert—is mostly creosote bush and bursage with widely scattered mesquite, palo verde, ironwood, and catclaw. A variety of cacti punctuate this landscape.

By Richard Brook, Gary Stumpf, and Mary Tisdale

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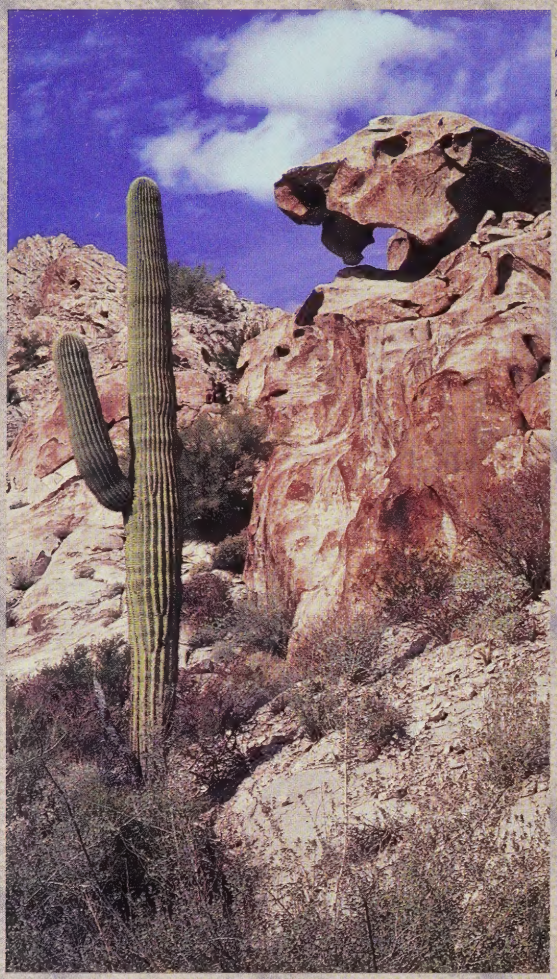


Diane Drobka

The saguaro, the largest cactus found in the United States, is the symbol of the Sonoran Desert, even though it does not occur throughout this desert. The largest of the saguaros can tower 15 meters above the desert floor and weigh 6 to 7 metric tons at 150 to 200 years of age.

Saguaros take an incredibly long time to mature. After 10 years, they may measure only 10 to 15 centimeters. The first flowers don't appear until the plant is 30 to 40 years of age. The distinctive armlike branches may not appear until the saguaro is almost 75 years of age.

The saguaro can absorb 760 liters—an amount that will allow the cactus to survive for a year—from a single, infrequent rainstorm. What allows the saguaro to absorb water so quickly is its extensive but shallow root system, which may extend outward from 9 to 18 meters in all directions. This system allows the saguaro to thrive, but also permits the plant to be easily uprooted by cactus thieves, who can earn more than a $1,000 from the sale of a single desert giant.

Saguaros are an important focal point for many animal species. Most saguaros are pockmarked with round holes drilled by Gila woodpeckers and northern flickers searching for larvae or hollowing out nest sites. Abandoned holes become homes for screech owls, pygmy owls, or tiny elf owls.

The remaining two-thirds of the Sonoran Desert, to the east, lie at higher elevations and support a much greater density of succulent plants. Here, the giant saguaro flourishes, growing in forestlike stands interspersed with thickets of mesquite, acacias, ironwood, and palo verde. The bursage and creosote growing at lower elevations give way to yuccas, agaves, beargrass, barrel cactus, cholla, and prickly pear. Oak, juniper, and pinyon pine grow on the mountains rising above the desert floor. The seeds, stems, and leaves of many of these plants provide rich food sources, sustaining populations of deer, bighorn sheep, javelina, reptiles, rabbits, and other rodents.

Perhaps the most recognizable symbol of the Sonoran Desert is the giant saguaro cactus, but many other cacti add their distinctive shapes and spectacular flowers to this landscape, including the tall columns of the organ pipe and senita and the squat forms of the cholla and prickly pear. The ocotillo's thorny, sticklike branches rise from the ground, ready to sprout green leaves at the first touch of rain. Burro brush, brittlebush, desert broom, and sotol fill in beneath taller plants. Agave—once cultivated as an important food crop by the Hohokam Indians a thousand years ago—also grows here.

What makes the Sonoran Desert such a place of abundance? In a word, water. The Sonoran Desert has two rainy seasons: winter and summer. The winter rains of December through March come from the west, while the summer rains move east from the Gulf of Mexico, primarily in July and August. These summer "monsoon" rains bring awesome thunder and lightning storms accompanied by drenching downpours that briefly break the intense heat and cause the desert to bloom anew.

In addition to having two rainy seasons, this arid region is bordered by mountains in Colorado, Arizona, and the Mexican state of Sonora, which receive much greater rainfall and snowfall. The water trapped by these mountains drains into rivers that cross the desert, some of them maintaining corridors of riparian vegetation during even the driest months of the year. The Colorado River runs year-round, and the Gila River was a nearly constant stream before dams were built on it. Until the mid-nineteenth century, the San Pedro River ran year-round, and the Santa Cruz River ran intermittently with long stretches of surface flow.

Sonoran plants and animals have developed some unique and innovative ways to survive. The roots of the mesquite tree bore as deep as 30 meters to find moisture. Some hardy desert perennials simply die back above ground when the moisture regime is unfavorable. Such plants survive through a variety of remarkable underground structures, such as thickened roots, bulbs, tubers, rhizomes, and nodules of many designs and dimensions.

The ironwood tree produces leaves during favorable moisture conditions, but rapidly sheds them under moisture stress, opting instead to conduct photosynthesis in its trunk and branches. The ocotillo, too, has high water needs when it is in full leaf, but, at the first hint of drought, it sheds its leaves.

The creosote bush has a highly competitive root system capable of drawing almost all available moisture from the soil. The uniform spacing of creosote bushes, as seen from the air, is the result of root competition for the small amounts of water available in the area.

Some old and strong desert shrubs

Marty Cordano

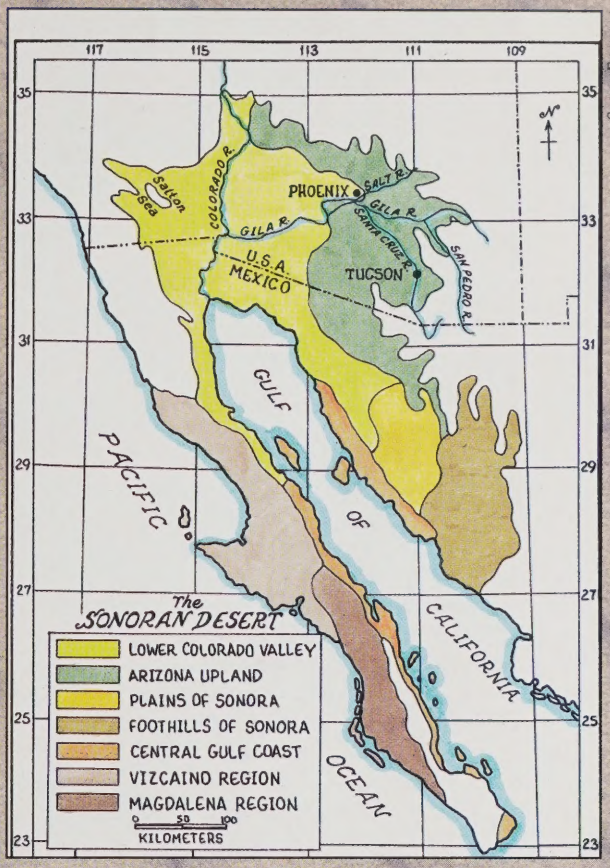
Ringtail cats are related to the raccoon and are strictly nocturnal animals. About the size of a housecat, miners often kept them to catch mice.

conduct chemical warfare against younger and weaker plants. The leaves of the brittlebush and guayale poison the seedlings of many other plants, prohibiting their growth.

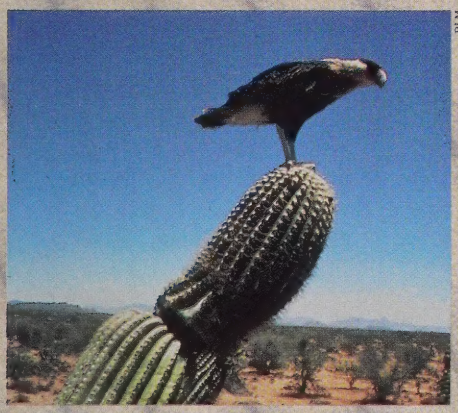
Seeds of the palo verde, ironwood, and smoke trees have extremely hard coats. Before these seeds can germinate they must be abraded; this occurs when the seeds lying in the bed of a wash (a dry river bed) are caught up in the occasional flood. If sufficient water is still present, the plant will grow.

Other plants, called drought evaders, don't resist drought but avoid it altogether. These plants persist only as seeds, ready to spring up when it rains, flower quickly, produce another crop of seeds, and then die.

Animals, too, have developed special tools for survival. Among the best adapted is one of the smallest of all desert mammals, the kangaroo rat. These rodents can make long, swift leaps with their powerful hind legs to escape predators. Using their tails as rudders, they can change course in midair. These mammals can survive their entire lives without drinking a drop of water. Instead, they obtain moisture primarily from dry seeds, which contain up to four percent water, and from an occasional leaf or insect. A complex moisture-conservation system also protects the kangaroo rat from dehydration. Its metabolic system is highly efficient at recycling and retaining water so that very little moisture is lost through urination; what does pass out looks like a concentrated paste or crystals. A specially designed respiratory system cools the rat's breath before it can be exhaled through the nasal passages and condenses the moisture into minuscule droplets, which are then reabsorbed into the rat's body.



SHELLY FISCHMAN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The crested caracara, also known as the Mexican eagle, is often seen majestically perched on saguaro or organ pipe cacti. It typically does not hunt for food, eating carrion instead.

Hedgehog cacti flowers. The buds form under the surface of the cactus' ribs and then burst through the tissue.

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One of the best known of desert birds is the greater roadrunner. This bird spends almost its entire life on the ground running, attaining speeds of up to 40 kilometers per hour. Oddly, running uses fewer muscles than flying, making it a less strenuous method of movement.

The spadefoot toad is one of the most persistent of the desert dwellers. A horny projection on each hind foot serves as a digging tool. When drought sets in, the toad burrows backward deep into the ground and begins a period of estivation, a state akin to hibernation. Its underground cell is lined with a gelatinous substance, secreted by the toad itself, that greatly reduces water loss. The period of estivation lasts eight or nine months of the year, until a cloudburst saturates the soil, awakens the toad, and creates a frenzy of activity that results in mating and the hatching of tadpoles in a day or two.

Management Challenges

The land ownership pattern in the Sonoran Desert is a checkerboard of public, tribal, and private ownership. The Bureau of Land Management of the U.S. Department of the Interior oversees large tracts of land in the Sonoran Desert along with other entities, including Indian tribes. Some 30 million people surrounding the desert have a growing interest in these open spaces. More and more, urban and suburban dwellers in Tucson, Phoenix, and Southern California are looking to these public lands for natural resources, recreation, urban development and other uses. The challenge is to manage these varied uses while sustaining the desert's fragile balance.

Recreation

Seeking escape from crowded urban areas, many people turn to the Sonoran's open spaces for solace and recreation. Designating special areas for recreation is one strategy land managers are pursuing to cope with the influx of visitors. This strategy was adopted at the Imperial Sand Dunes in Southern California.

Thought to be beach sands from ancient Lake Cahuilla, the Imperial Sand Dunes are the most popular destination in the Sonoran. Over a half million visitors come to this "play area" each year to

explore the dunes in off-highway vehicles, which are designed for use on unimproved roads or back country areas. In 1994, Congress designated the northern part of the dunes as a wilderness area, while allowing vehicular use in the southern portion.

A management plan for the dunes area outlines over 200 actions for managing the visitors and protecting dune resources. Volunteers work with federal and state land managers to patrol the area and conduct education programs promoting public safety and resource conservation. Volunteers also donate over 7,500 hours annually to assist law enforcement officers in protecting the area.

The Long-Term Visitor Area (LTVA) program is another effort to concentrate visitors in designated areas, keeping campers from the back country where more impacts would occur. Seeking refuge from winter weather, thousands of people from across the northern United States and the Canadian provinces take up residence on public lands in the Sonoran and Mojave Deserts. In 1983, the Bureau of Land Management established the LTVA program to respond to this annual migration of "snowbirds." For a nominal fee, campers spend the winter months in any one of eight LTVAs. The program has been successful in reducing trash and other disturbances to the desert. At the same time, water, toilets, refuse disposal, and waste dump stations provide a cleaner environment and amenities for visitors.

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Long-Term Visitor Areas (LTVAs) provide facilities for campers while concentrating them away from the back country where camping would have adverse impacts.

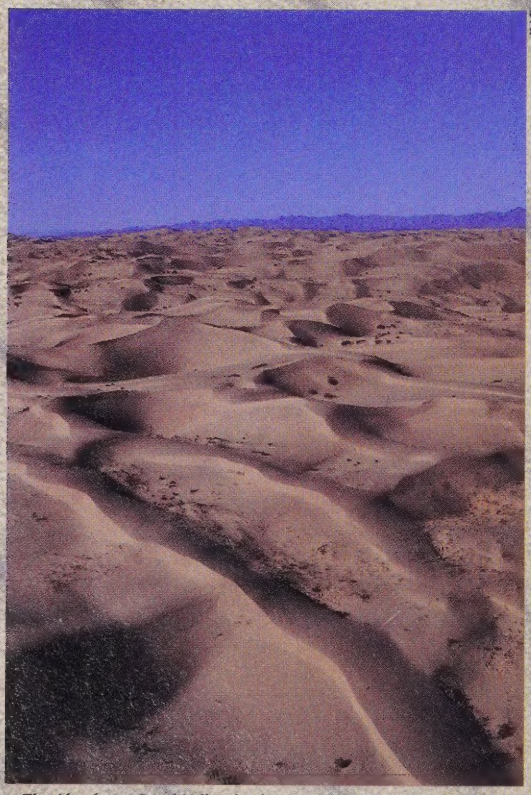
Exotic Plants

Some plants found in the Sonoran Desert today, such as red brome, yellow star thistle, Malta star thistle, buffel grass, and tamarisk (saltcedar), do not belong there. They were introduced from other countries and are called exotic, alien, or non-native species. For example, the tamarisk was planted as a shade tree and to control wind and erosion. It came originally from the Mediterranean area and can tolerate salty soils.

In its native range, saltcedar populations are restricted by natural pests, such as insects and diseases. But these pests were not introduced into the United States along with the saltcedar. Thus, weedy saltcedar species can expand their range anywhere the climate is suitable.

Saltcedar grows well in sandy, moist soils and has invaded riverbanks and natural springs, competing with native species for precious water sources. The two most common native plants displaced by a saltcedar invasion are cottonwoods and willows growing along rivers and streams. In some areas, mesquites are also eventually displaced by saltcedar. Once established, it prevents native grasses, forbs, and shrubs from recovering by exuding salts from its leaves, which increases the salinity of the surrounding soil beyond the tolerance of natives.

The invasion of the desert by saltcedar can also affect native wildlife. In the United States, saltcedar is not commonly eaten by native herbivores, such as bighorn sheep and deer, and the plant's seeds are too small to be a food source for birds or rodents. Control and eradication programs are being conducted throughout the western United States. In most cases, the goal is to preserve or recover sensitive areas. Eliminating massive infestations along major rivers is not economically feasible at present.



RAB

The Algodones Sand Hills, also known as the Imperial Sand Dunes, are a favorite visitor attraction in Southern California. They are believed to be ancient beach sands.

Threatened and Endangered Species

Communities are also turning to public lands for expansion and development. Protecting unique habitats, particularly for threatened and endangered species, can complicate these plans. The desert slender salamander, peninsular bighorn sheep, desert tortoise, southwestern willow flycatcher (a neotropical bird), and the Nichol's Turk's Head cactus are a few examples of species at risk. In most cases, creative and cooperative efforts provide the solutions. The Coachella Valley Fringe-Toed Lizard Preserve is one such example.

Since 1940, the population of the 520-square-kilometer Coachella Valley in Southern California has jumped from 12,000 to 220,000. This development seriously encroached on the habitat of the Coachella Valley fringe-toed lizard and the free-flowing sand that sustained it. In 1980, the U.S. Department of the Interior listed the lizard as "threatened" under the Endangered Species Act and construction came to a virtual standstill. Since then developers, environmental organizations, and local, state, and federal agencies have worked together to establish and maintain a self-sustaining ecosystem (the Coachella Valley Preserve); the fringe-toed

lizard is an integral part of this ecosystem. Developers pay a fee as compensation for the development of private land outside the preserve. The fees collected are then used to acquire lands for the preserve. The Nature Conservancy manages the day-to-day operations, guided by a committee of agencies and groups. A federal ranger helps control unauthorized vehicle use and other violations.

The Santa Rosa Mountains, designated as a National Scenic Area in 1990, are another example of public and private collaboration to protect sensitive resources. The area is home for such endangered species as the desert slender salamander and peninsular bighorn sheep, as well as more than 500 species of plants. It has provided sustenance for Indians for thousands of years.

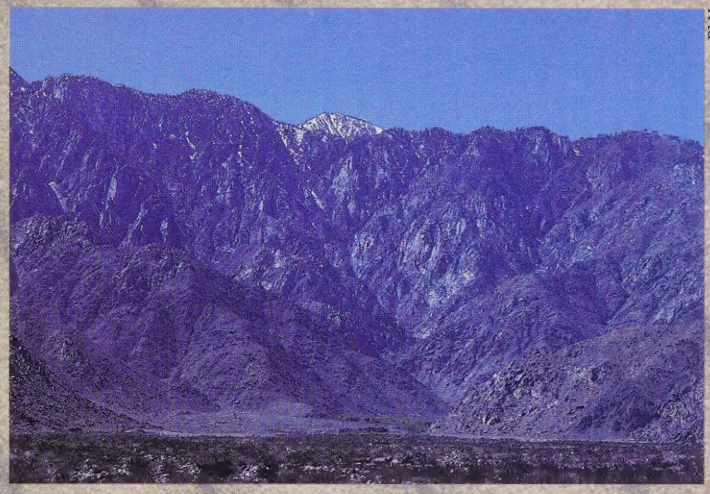
The area encompasses approximately 80,000 hectares of the Santa Rosa and San Jacinto Mountains. The federal government, the state of California, and Indian tribes own approximately 70 percent of this area. Because the remaining privately owned land includes important areas critical to the protection of wildlife and other resources, government agencies, conservation organizations, and other entities have been working since 1990 to acquire private lands in the Santa Rosas and involve the public in the preparation of a long-term resource management plan for this area. In April 1996, a visitor center opened with the help of the city of Palm Desert and local volunteers who help staff the center.

Large-scale, long-term cooperative efforts such as the Coachella Valley Preserve and the Santa Rosa National Scenic Area will become more and more important as the population surrounding the Sonoran Desert increases and demands for uses of the desert continue to grow.

American Indian Traditional Cultural Places

Many American Indian traditional cultural places are located in the Sonoran Desert, within tribal reservations but also on the public lands. Information about such areas is often very sensitive and, by tradition, is not shared with uninitiated members of a tribe or with people outside the tribe. This makes it difficult for managers to protect these places when making decisions about actions that could damage or destroy them.

Even when sacred areas are known, issues can arise regarding their designations and uses. Places valued by Indians for cultural reasons are often valued by other groups, such as recreationists or commodity interests, for different reasons. In these situations, land managers strive for compromise, but sometimes this is not easily achieved.



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Southern California's Santa Rosa Mountains are a National Scenic Area and the home to many endangered species. They are also a sacred area to Indians.

Riparian Areas

Riparian areas—the lush green areas of vegetation bordering lakes, ponds, rivers, streams, and wet meadows—are lifelines in the desert. More than 90 percent of the historic riparian areas in the Southwest have been lost, in large part as a result of the damming of rivers.

One of the most important riparian areas in the United States runs through the Chihuahuan Desert and the Sonoran Desert in southeastern Arizona along the San Pedro River. Despite the dryness of the surrounding land, it sustains one of the richest wildlife populations in the country.

To protect its remarkable resources, federal land managers acquired a 58-kilometer segment of the San Pedro River north of the Arizona-Mexico border in 1986. Legislation passed by Congress in 1988 designated this segment of more than 22,400 hectares a Riparian National Conservation Area. This "ribbon of life" represents the most extensive, healthy riparian ecosystem remaining in the desert Southwest.

U.S. Fish & Wildlife Service

When enemies threaten, the fringe-toed sand lizard dives into the sandy soil and swims out of sight in seconds. Specially constructed scaly fringes on its toes make this vanishing act possible, while a built-in sand trap in its nose enables it to breathe under the sand without choking.

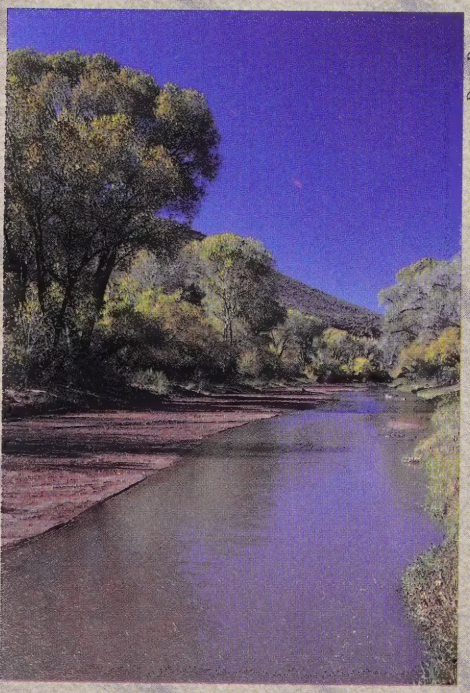
The conservation area is home to 82 species of mammals, 12 species of fish, 47 species of reptiles and amphibians, and 100 species of breeding birds. It provides an invaluable habitat for another 250 species of migrant and wintering birds. Some of these birds, called neotropical migratory birds, breed in North America and winter south of the United States. Birds inhabiting the area include yellow-billed cuckoos, Crissal thrashers, green kingfishers, vermilion flycatchers, elf owls, Lucy's warblers, Botteri's sparrows, yellow-breasted chats, Bell's vireo, and gray hawks. The gray hawks on the San Pedro River represent about 30 percent of the nesting gray hawks in the United States.

The same water and vegetation that attracts animals to the San Pedro River has attracted humans for thousands of years. In fact, the area contains archaeological sites representing the remains of human occupation from before the end of the Pleistocene, 11,200 years ago, up to the present. The earliest sites contain the remains of mammoths and bison with the stone tools of the people who hunted

them. Archaeologists call these earliest big game hunters the Clovis people. Of the handful of Clovis sites in North America, six have been found in this area.

After the Clovis people, other Native Americans lived along the San Pedro River, eventually encountering the first Europeans to enter the area. Francisco Vasquez de Coronado likely followed the San Pedro River in 1540 on his exploratory expedition into what is now Arizona. More than 200 years later, Spain built a fort, or Presidio, beside the San Pedro River to protect the northern border of its New World empire. Remnants of the Presidio, Santa Cruz de Terrenate, still stand (See "Science in Process: Discovering the Past at Santa Cruz," *Science and Children*, April 1992 for more information about the Presidio.) Miners later built millsites. In the 1880s, a railroad was constructed along the river, and the Fairbank townsite was built to serve as a depot. Now a "ghost town" that is slowly being restored, Fairbank is a point of interest for the recent influx of tourists who ride the train today.

Some of the activities that affect the riparian ecosystem include water pumping for agricultural and residential purposes, livestock grazing, sand and gravel operations, firewood cutting, vehicle traffic, and recreational activities. If not properly managed, these activities could adversely affect the water quality, riparian vegetation, wildlife, archaeological sites, fossils, and soils.



DIANE DROBKA

When water flows through the desert it provides a unique habitat. The San Pedro River, a perennial stream, sustains one of the richest wildlife populations in the United States.

After working with the public to consider various alternatives, land managers have adopted a series of actions to protect this important riparian ecosystem. Since the primary purpose for obtaining the lands along the San Pedro River was to enhance the riparian ecosystem, land managers have prohibited livestock grazing for at least 15 years. Sand and gravel extraction will also be prohibited in the riparian zone. Motor vehicles and mountain bikes are restricted to designated roads, and campground stays are limited to seven days. To improve wildlife habitat, managers will develop ponds and marshes, plant trees and other native vegetation, install nest boxes, and work with others along the San Pedro on water usage and conservation.

Interpretive displays and trails as well as environmental education field study areas will inform the public about these sensitive resources. Three areas designated as "Areas of Critical Environmental Concern" will be managed with special care. Developed campgrounds, picnic sites, and historic and archaeological sites for the public to visit will accommodate the growing demands for recreation. With the adoption of these and many other protective measures, land managers hope to preserve the integrity of this critical riparian ecosystem long into the future.

The benefits of protecting the health of the San Pedro riparian ecosystem and other riparian areas throughout the West are extensive. When a riparian area is healthy and functioning, its lush vegetation slows the flow of water, allowing it to soak into the soil and recharge the water table. In many cases, as groundwater storage is enhanced, intermittent streams begin to flow year-round. Riparian vegetation along upper watershed streams can absorb and dissipate the energy of floodwaters, reducing downstream damage. Plant roots bind and hold settled soils in place while stems and foliage filter and settle sediments, resulting in the building and protection of stream banks. Healthy riparian areas also reduce sedimentation in reservoirs, extending their effective life and improving water quality. They also help control nonpoint-source pollution.

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The summer tanager, a visitor to the San Pedro riparian habitat, is a neotropical migratory bird with a robinlike song. Its diet consists of insects and fruits.

The restoration of perennial streamflow provides water for wildlife during the normally dry summer months, reducing the need for expensive water developments.

Many wildlife species depend on the unique and diverse habitats offered by riparian areas. This habitat provides food, water, shade, and cover—necessities for wildlife and livestock. Riparian vegetation is of critical importance to fish. It provides escape cover, lowers summer water temperatures through shading, and reduces stream bank erosion that can lead to silt in spawning and rearing areas. Enhancing riparian areas also increases opportunities for recreation, such as camping, hiking, bird watching, photography, fishing, hunting, and simple relaxation.

Looking to the Future

The Sonoran Desert is a magnificent but fragile ecosystem. Many of the threats facing this environment relate to how people choose to use the resources of this land. If treated with respect and care, it will be a place of beauty and diversity for many generations. Educating today's youth about the area's many distinctive plants, animals, and other natural features will help them make good decisions about managing the resources of the desert in the future.

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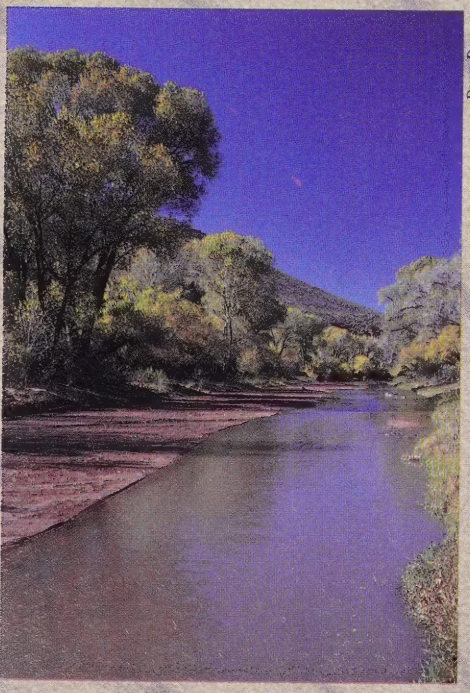

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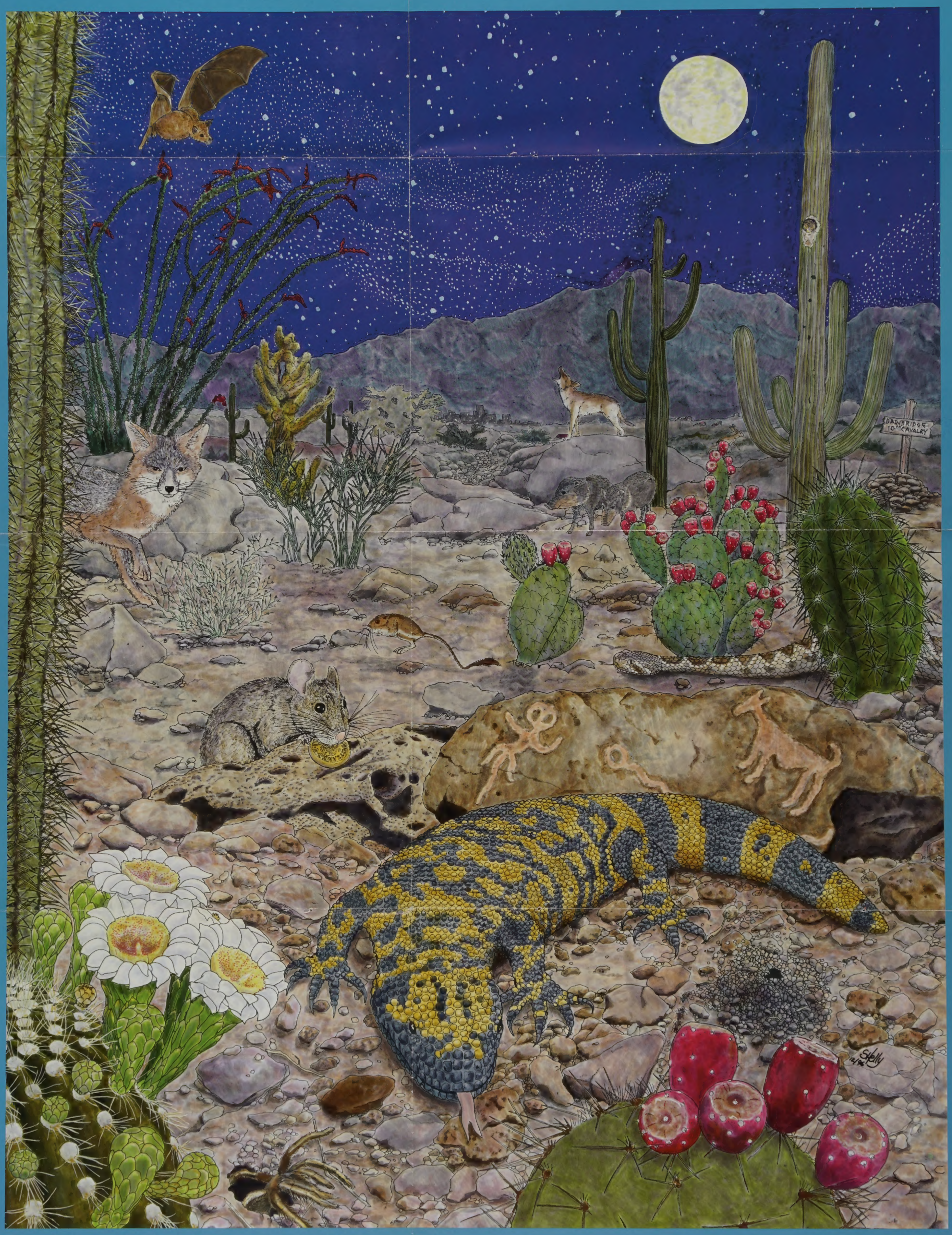
In the Still of the Night

The Sonoran Desert Ecosystem



Department of the Interior, Bureau of Land Management

Artwork and associated research by Shelly Fischman

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Department of the Interior, Bureau of Land Management

FOR THE CLASSROOM

Who Lives Here?

One of the greatest threats to plants and animals today is habitat depletion. Discuss some of the human activities that are changing the desert (need for more homes, increased roads, increased demand for recreation, desire to make the desert like another habitat by introducing exotic species). Have students research descriptions, accounts, and photographs of their local area as it was seen by early pioneers and explorers. Compare and contrast the area today with how it was in the past. What native plants and animals have become threatened, endangered, or extinct? What exotic plants and animals now live in this area? Locate natural springs and other natural water sources. Are these water sources still accessible to wildlife? What actions can students take to protect plants and animals near their homes?

Join the Club

Divide students into four groups. Assign each group to one of the following "clubs," each representing a particular plant adaptation for coping with the heat.

J. Scovil

The minerals of the Sonoran Desert are very important to the economy of Arizona as well as the United States. In 1995, the value of nonfuel production in Arizona, almost entirely from the Sonoran Desert, was about $3 billion, the highest in the nation. Production of copper from copper-bearing minerals of Arizona's Sonoran Desert accounts for about 60 percent of the nation's copper output. The Sonoran Desert has examples of minerals-such as wulfenite (beautiful reddish-orange crystals), the gemstone peridot, malachite, and azurite-which are prized by both amateur and professional collectors.

The blue color of this sample of malachite and azurite is characteristic of copper-bearing minerals. This specimen is from the Czar Shaft Mine in Bisbee, Arizona.

Suntan Lotion Lovers: Many plants limit the amount of moisture they can lose through evaporation by covering their leaves or pads with a waxy coating. This works much the same as suntan lotion or sunscreen in protecting us from "drying out" in the sun.

White Shirt Specials: Since light colors work to reflect the sun's rays, some plants "wear" light colors to keep cool and, in doing so, retain more moisture. Many desert plants have white leaves or hairy surfaces that work just as a white shirt to reflect the sun's rays.

Make Your Own Shade Club: If a plant is kept cool, it will lose less water through evaporation. Many plants are able to keep themselves somewhat cooler than the surrounding air temperature by "making their own shade." Spines on cacti and leaves on trees create shade for those plants.

Canteen Kids: Some plants are able to store large amounts of water in their thick leaves or stems. Members of this group are called *succulents*. Cacti are a good example of succulents. After water is taken up by the roots, it is then chemically changed by the cactus into a mucilaginous substance that does not evaporate as quickly as the watery sap found in large-leafed plants. This moisture is stored in the stem.

Ask each group to conduct research to identify desert plants that belong to their "club." On a bulletin board, have students display pictures of the plants in their club, together with descriptions about their special adaptations.

Creature Feature

Introduce students to the term *riparian zone*. This is an area that includes not only the water, but also the vegetation associated with the water. Many animals living in this area could not survive without the special conditions that the riparian zone provides. Riparian areas often provide different and more abundant vegetation than surrounding areas, a higher percentage of shade trees for nesting or shelter, higher humidity, and more diverse plant and animal life. Riparian areas are easily affected by natural and human-made changes.

Have students work in small groups to design a creature adapted to living in a riparian area. While they are designing the creature, have them consider the following questions:

- How are its feet adapted to the environment?
- What kind of body covering does it have that makes it well suited for living in an aquatic area (scales, feathers, shell)?
- Where are its eyes? How can it see above and below?
- How does it move (swim, fly, carried on current)?
- What does it eat? How is its mouth adapted to this kind of food?
- What kind of limbs does it have (arms, legs, flippers, gills, wings, tail)?
- What special adaptations does it have for surviving in a desert region (surviving flash floods, drought)?

Have students share their creatures with the class, discussing ways each animal has adapted to an aquatic habitat.

Extension: Talk about threats to riparian habitats. How would this creature adapt to these and other human-made changes? Would this creature disappear or would it adapt? What could be done to help protect this animal and still satisfy our water needs?

Planning a Conservation Community

Ideally, communities would not intrude on the desert's beauty to accommodate expanding growth and development. In some cases, however, communities "boxed in" by water or other features may have limited choices. In these cases, planning is critical to minimize impacts to the natural environment.

Have students work in teams to create a map of a "desert community" that demonstrates the importance of protecting the desert's fragile resources. Ask students to brainstorm a list of the facilities, resources, and services that their community would have. Consider the following questions:

- How do people get the food they need?
- Where do they live?

In the Still of the Night

by Richard Brook, Shelly Fischman, Gary Stumpf, and Mary Tisdale

SCIENCE & CHILDREN

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Somewhere in the distance a coyote howled . . . .

Deserts don't settle down for the night, they perk up. Critters hunt in the cool evening air. Bats take flight hunting insects, and in the process, pollinate saguaro cacti. A gray fox prowls. A pack rat (also known as a wood rat) scurries about with its shiny treasure, an old Spanish gold piece perhaps dropped by Conquistadors in search of the Seven Cities of Gold. Just to the left, a rock with petroglyphs of a quadruped, snake, and lizard bears silent testimony to the long-gone Hohokam civilization. A Gila monster, one of the world's two species of poisonous lizards, lumbers about. It may be poisonous but it's hardly aggressive. Nearby, a tarantula emerges from its den—not pleasant to look upon, but also not poisonous as widely believed.

Ants leave their nest as a team to forage for themselves and their queen at an amazing rate of speed. Also depending on its speed, a kangaroo rat evades a western diamondback rattlesnake out looking for dinner. Collared peccaries (javelina) stand nearby. A black-tailed jackrabbit speeds along, zigzagging to confuse potential predators, while an elf owl watches from its nest in a saguaro cactus. And then there's that coyote.

If the Sonoran Desert is the stage, these wild critters are the cast, and the desert flora are the scenery. The arms of the saguaro (pronounced "soo-r-o") cactus stretch upward toward the sky. Its flowers stay open at night and its skin swells or contracts depending on the availability of water. Other important flora include the barrel cactus, shown in the illustration tilting toward the moon, and Englemann's prickly pear cactus, with its flat, pan-shaped leaves supporting edible, tasty red fruit that are a sign of the early summer.

Another cactus is the teddy bear cholla—interesting to look at, but don't get too close, for its spines are barbed and difficult to remove from skin or flesh. Other flora include the ocotillo, a cactuslike tree waving its red-tipped whips in the night air, as well as mesquite and Palo Verde trees situated along the arroyo. Some grasses can be found as well, the bush muhly near the fox in the illustration and prairie threeawn a little farther back.

The Sonoran ecosystem can be tough and often unforgiving. The city in the distance attests to the fact that people can and do live here. But the grave of the Buffalo Soldier shows that people can succumb to the harsh climate. Rocky soils reflect the lack of organic material. The sharp edges of the rocks confirm that erosion is often the result of the freeze/thaw cycle, which cracks rocks rather than rolling them around and smoothing their edges (as in a stream bed). And while water isn't plentiful in this environment, it does make appearances in the form of quick, violent storms that turn the normally quiet and dry arroyos into raging, torrent-filled channels.

A land that is starkly beautiful, dangerous, tempting, and fascinating—the Sonoran ecosystem.

The Question in Brookdale

Activity 1

The Question in Brookdale

Using this role-playing activity, students become acquainted with some of the processes used by resource agencies in making land use decisions. They consider whether a parcel of land currently managed by a natural resource agency should be made available to a local community for development purposes. The activity introduces students to the challenges resource managers face in attempting to accommodate competing demands for uses of the land while maintaining its ecological integrity.

The activity will take several days for students—preparation and two or three hours for each "public meeting."

Procedure

Begin by photocopying the "position cards" below (one for each group of three to five students) and the background passage (one per student). Have the class read the background passage and then form small groups. Give each group a position card.

Instruct members of each group to prepare an argument for the point of view represented on their position card and consider how to present their case to the resource managers. Over the next several days, the students should conduct library research to learn how communities might have handled similar situations. For example, depending on the group they are representing, students might search for information on off-highway vehicles, personal watercraft, speedboats, or other recreational subjects, or on endangered or threatened species such as the desert tortoise or fringe-toed lizard. Students could also look for examples that specifically involve areas within or bordering the Sonoran Desert, such as the Algodones Dunes (also referred to as the Imperial Dunes) or the Colorado River.

To prepare their arguments, students may also interview city planners, staff from natural resource agencies, or other professionals engaged in resource management or land use planning to explore how they might approach the question of land use. Each group might also want to designate a spokesperson.

At the "public meeting," have the resource agency group sit in front of the class. Members of this group could be students invited from another class or representatives from each of the interest groups. Give each group five minutes in which to state its position. Students representing the resource agency can question each of the spokespersons from the interest groups.

After all groups have presented their positions, lead students in a general discussion. Make sure students see that each group does have a valid concern and that there is no "right" or "wrong" in this situation. The resource agency should decide whether or not to amend the land use plan and identify the parcel as suitable for sale to the community of Brookdale. If the students representing the resource agency determine that the parcel is not suitable for sale, ask them to propose one or more alternatives to address the community's need to expand.

After the resource agency makes its decision and/or offers its alternative(s), have students reassemble in groups made up of one person from each of the interest groups, with the exception of the resource agency. These new groups should consider the agency's alternative(s), or come up with their own alternative, and prepare to make another public presentation. In their presentations they should address how the agency's concerns, as well as those of the other various interest groups, will be addressed. Challenge each group to suggest an alternative that addresses human needs as well as the long-term health of the ecosystem.

During their discussion, encourage students to consider the following questions:

- What else would you like to know about this ecosystem? Would it be helpful, for example, to have an inventory of the area's threatened and endangered plants and animals?
- What are some things about the citizens and their community that would be useful to know?
- How do the values of the various interest groups differ?
- Does the community of Brookdale have a long-range plan that will ensure that future development is, in fact, limited to low-density development?
- Does the availability of similar recreational and long-term visitor areas nearby affect your recommendation?
- What is the best use of the general area in regard to human interests? What about in regard to protecting biodiversity? Are there solutions that can satisfy both?
- What can you give up or alter about your position?
- How would the knowledge that Indian tribes consider the Tipaza Hills significant in its entirety, and that no mitigation of the adverse impacts of development is possible, affect your recommendation?

Background

The community of Brookdale, located along the lower Colorado River, in the Arizona portion of the Sonoran Desert, has approached the local land-managing agency about acquiring a parcel of public land adjoining its town to the north. The community is interested in attracting some of the "snowbirds"—visitors from the northern United States and Canada—who annually migrate to Arizona and California during the winter months. The community would also like to take advantage of some of the expanding recreational activities that are focused around the Colorado River.

The parcel that Brookdale wishes to acquire includes mostly level terrain overlooking the Colorado River, but also includes a small range of mountains that may eventually figure into the town's development plans.

Brookdale has limited opportunities for town expansion because it is surrounded along the west side by the Colorado River and on the north, east, and south by public land. As opposed to the public lands to the north of Brookdale, the lands on the east and south do not offer vistas of the Colorado River. The town's river-oriented recreational opportunities (predominately personal watercraft and speedboats) would directly compete with several other private and public facilities located on the California side of the Colorado River, as well as a long-term visitor area located on public lands approximately 32 kilometers east of the river.

In the land use plan prepared many years ago, the parcel that Brookdale wants to acquire was not identified as available for sale. The community of Brookdale would like the resource agency to amend the original land use plan to designate the parcel as suitable for sale. The agency will conduct a public meeting to solicit input from the various interest groups who may be affected by the land use decision.

The resource agency already has on file certain information related to the parcel. Specifically, the agency has received information from numerous Indian tribes that the parcel includes an area that is of traditional cultural importance to Indian tribes in Arizona, California, and Mexico. The area, known as the Tipaza Hills, is valued by these groups as a spiritual retreat and a location for conducting special ceremonial activities.

Also, biologists working for the resource agency have noted that several caves located in the Tipaza Hills are a critical habitat for a species of saguaro-pollinating bats. Biologists believe that an apparent decline in the number of young saguaro cacti may be attributable to a decline in the number of these bats and that an increase in insect infestation in agricultural areas farther downstream along the Colorado River may also be attributable to a decline in these bats, which also eat insects. Biologists are uncertain how widely distributed this bat species is within the Sonoran Desert, or how closely related genetically it is to other bats in the Sonoran.

Recreationists

Recreationists would like a broad level of high-quality recreational experiences made available at a reasonable cost and with a minimum number of restrictions. Additionally, they want the experience to be safe and family-friendly. They want

- an attractive area to camp (with facilities such as toilets and showers) and to spend their leisure time;
- additional recreational destinations along the Colorado River;
- stores that sell and rent river-oriented recreational gear;
- fresh water for drinking and outdoor swimming;
- facilities directly accessible from the river to purchase gasoline, supplies, fresh water, and recreational equipment;
- and specially designated areas for speedboats, personal watercraft, fishing, inner-tubing, hiking, and bird-watching.

Long-Term Visitors

Long-term visitors (also known as "snowbirds") are visitors from colder climates who spend the winter months in designated camping areas on public lands in Arizona and California. They want

- hiking trails developed overlooking the Colorado River;
- their own recreational facilities that are separate from river-oriented recreational facilities;
- non-native trees planted for shade;
- an outdoor pool, toilets, and fresh water;
- and a minimum of modern developments around the long-term visitor areas.

Biologists

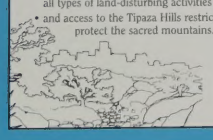
Biologists would like to see native plants and animals protected in the wild. They want

- minimal disruption of the existing ecosystem;
- critical bat habitat protected;
- a buffer area between human developments and critical plant and animal habitats;
- the greatest possible diversity of native plants and animal species;
- and an inventory of existing flora and fauna.

American Indian Tribes

Indian tribes want unrestricted access to sacred and traditional use areas located on public lands and restrictions on access to these areas by non-Indians. They want

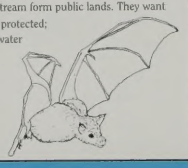
- the Tipaza Hills made off limits for mineral extraction and all types of land-disturbing activities in perpetuity;
- and access to the Tipaza Hills restricted to Indian tribes to protect the sacred mountains.



Farmers

Farmers are concerned about the effects of federal actions on the productivity of privately owned farmlands and the availability of water for irrigation downstream form public lands. They want

- insect-eating animals protected;
- and upstream use of water from underground aquifers limited.



Brookdale Chamber of Commerce

Members of the Brookdale Chamber of Commerce want

- the federal parcel of land acquired for low-density developments;
- some level of economic growth promoted without significantly changing the "smalltown" character of their town;
- long-term visitors who will spend money but only stay part of the year;
- and a limited level of development to accommodate the long-term visitor.

Waxy Leaves

Activity 2

Waxy Leaves

Desert plants known as drought resisters include a variety of shrubs and other woody or fibrous plants. These plants can take the worst the desert has to offer. Cacti store moisture in their spongy stems or root tissues during periods of rain, then use it sparingly during times of drought. Other plants, such as the catclaw, the acacia, and the mesquite, have deep and widespread root systems to capture all available moisture.

Many drought resisters, such as the creosote bush, have tiny leaves and/or coat their leaves with a waxy, resinous substance to reduce moisture loss. The following activity illustrates how one of these adaptations ("waxy" leaves) prevents water vapor from escaping from a plant, allowing the plant to retain its moisture for use during hot, dry periods.

Materials

For each group of students, you will need two plastic bags, two potted seedlings, petroleum jelly, adhesive labels, a measuring cup, and water.

Procedure

Instruct the students to add the same amount of water to both plants. Have them label one plastic bag "petroleum jelly" and the other bag "no petroleum jelly."

Students should place one seedling in the bag labeled "no petroleum jelly," seal the bag, and put it in a sunny window. Next, they should rub petroleum jelly on the bottom of all the leaves of the second plant, put this seedling in the other bag, seal the bag, and place it next to the first plant.

Wait several hours or overnight, then ask students to observe the bags and identify if either bag has water droplets collected on the sides. Discuss the following questions with students:

- Where does the water comes from? (It condenses from water vapor that passes out of the plant. The loss of water vapor through the stomata of a leaf is called transpiration.)
- What does the petroleum jelly prevent from happening? (It prevents water vapor from escaping from the plant.)

Liken the loss of water from the plant with petroleum jelly on its leaves to the creosote bush and other desert plants that have waxy leaves.

Animals of the Sonoran Desert

Lesser Longnose Bat. Bats fly by night by relying on their hearing rather than their poor eyesight. The return echo of their high-pitched voices bouncing off objects in their path (a kind of sonar) guides them through the skies and enables them to hunt airborne insects, many of which are costly agricultural pests. The lesser longnose bats are believed to be pollinators for many species of agave plants and serve as pollinators and seed-dispersers for dozens of species of columnar cacti, including the saguaro.

Western Diamondback Rattlesnake. Rattlesnakes eat small, warm-blooded mammals. Not fast enough to overtake their prey, they often wait coiled in ambush along rodent trails. Alerted to the approach of prey by its heat-sensing loreal pit, the rattlesnake will strike as the animal passes by. The victim runs for a little while until the venom kills it, after which the snake will uncoil and, once again guided by body heat, approach the victim and swallow it whole.

Gila Monster. A poisonous lizard with an undeserved bad reputation, the Gila monster is not aggressive and must actually chew on its victim to inject its poison (which is seldom fatal to humans). Gila monsters pick up and convey scents with their tongues and transmit them to a specialized sensory organ in the roofs of their mouths. Gila monsters can grow to a length of 50 centimeters and are patterned with pink, yellow, and black beadlike scales. They eat a variety of small mammals, lizards, insects, worms, and the remains of animals, which are swallowed whole. Bird and reptile eggs are also in their diet, but these are broken first.

Tarantula. These hairy spiders have adapted to the desert in part by burrowing into the ground to make their nests, thus avoiding the daytime heat. Hairy and as big as a human hand, they appear fierce but are not dangerous. A tarantula's venom is no more poisonous than that of a bee, and they rarely attack people. These spiders can live up to 20 years on their diet of insects, lizards, and other small animals.

Elf Owl. This raptor lives in abandoned nest holes dug in cactus flesh by Gila woodpeckers and Mearns flickers. Diminutive, saucer-eyed, and only 15 centimeters tall, the elf owl is the tiniest of the owls—but still deadly, with flexible toes for striking and gripping and a strong beak for tearing flesh.

Coyote. More often heard (as a howl in the desert night) than seen, this member of the dog family is a symbol of the Southwest. An adult male is about 110 centimeters long (including a 30-centimeter tail), and weighs about 10.5 kilograms. It can sprint 72 kilometers per hour and leap 6 meters in a bound, a useful talent for catching animals such as black-tailed jackrabbits, cottontails, kangaroo rats, and other rodents. The coyote is an omnivorous predator and scavenger, which helps it survive in the Sonoran ecosystem.

Gray Fox. A handsome animal, this fox has gray fur highlighted by a black stripe that runs down the top of its tail, along with orange or reddish patches along the sides of its throat. The gray fox stands about 35 centimeters high at the shoulder and, including its 22- to 43-centimeter tail, is 90 to 120 centimeters long. While its main diet is rodents, it will eat anything: mammals, birds, reptiles, plants, berries, dates, or tubers. Lacking in speed, the gray fox pounces like a cat, often from ambush. It also migrates like a bird, traveling to the coolness of higher altitudes during the summer and living in the canyons and flatlands in winter.

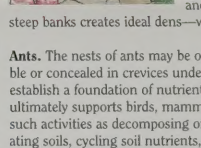
Kangaroo Rat. At 5 centimeters high with a tufted tail three times as long as its body, the kangaroo rat can cover ground at a rate of 5.1 meters per second. Using its tail as a rudder, it can make a 90-degree turn in midflight. The kangaroo rat lives in burrow communities 60 centimeters underground.

Relentlessly hunted, it serves as food for all of the carnivores in the Sonoran ecosystem, including bobcats, snakes, hawks, owls, and foxes. Living on grasses, seeds, and cactus pulp, the kangaroo rat may go its entire lifetime without drinking water. It survives by strict water economy. It has no sweat glands, passes no urine, and, by sealing itself inside its burrow during the day, it traps the moisture lost through breathing and allows some of the vapor to recirculate into its body.

Pack Rat. Also known as the wood rat or trade rat, this creature is surprisingly strong for its size, carrying away objects that appear too heavy for it to move. It collects shiny things and stores them in its nest, often dropping one "treasure" in favor of another (hence the name "trade rat"). In the desert environment, the pack rat gets the moisture it needs from green vegetation, primarily cactus juices. The rat's diet is a mixture of mesquite beans and the seeds of grasses and shrubs. Its nests usually resemble piles of rubbish, but they are a marvel of construction with thick walls of woven or shredded bark or coarse grass lined by softer fibers. The nest serves as both home and fortress, with several tunnels that provide easy entrance and exit.

Black-Tailed Jackrabbit. A far-from-particular vegetarian, this pale gray creature is not really a jackrabbit, but a hare. They grow to 60 centimeters in length, with a 7.5-centimeter black tail and 15-centimeter ears. Well suited to desert life, the black-tailed jackrabbit gets all the water it needs from plants, although it will drink water if it is easily available. It does not dig burrows, instead living the life of a wanderer. Hunted by most Sonoran carnivores, it eludes capture using its keen, protuberant, side-mounted eyes that give it a horizontal sight range of almost 360 degrees. Excellent hearing and a gait that goes from leaps to bounds, and then to a racing speed that no predator can obtain also help it to escape hungry predators.

Javelina or Collared Peccary. A relative of the pig that resembles a small razorback hog, these animals travel in bands of 10 to 20 and live in bushy areas. They grow to about 90 centimeters in length and 60 centimeters in height and are covered in coarse, grizzled, black and gray hair. Peccaries have razor-sharp teeth that are well suited to eating cactus and lechugilla, but they are not dangerous to humans. They must live near a source of water—succulent plants alone cannot sustain them. The twisting, vegetated washes of the Sonoran ecosystem offer peccaries concealment and shelter. Additionally, the erosion of the steep banks creates ideal dens—warm in winter and cool in summer.

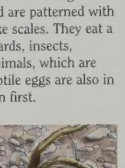


Ants. The nests of ants may be out in the open and highly visible or concealed in crevices under dead branches or rocks. Ants establish a foundation of nutrient and energy production that ultimately supports birds, mammals, and other wildlife through such activities as decomposing organic matter, moving and aerating soils, cycling soil nutrients, and dispersing seeds. Ant activities also increase soil moisture and contribute to nutrients near their nest. This often creates micro-habitats that support some plant species that grow solely in these localities. While being predators in their own right, ants also fill a niche near the bottom of the food chain.

Life in the Soil. Many of the animals and insects that move across the desert at night live under the surface. Rodents, snakes, spiders, wasps, termites, ants, and earthworms all make homes in burrows or nests underground. By far the greatest number of underground plants and animals are the microorganisms that live in the top 15 to 30 centimeters of the soil—bacteria, fungus, and moldlike plants, as well as millions of worms and single-celled protozoa. The dry Sonoran Desert climate results in soils that have fewer microorganisms and less organic matter than the moist soils of forests and prairies. Consequently, the microorganisms that are present are especially important as a source of nutrients, as a means of cycling nutrients, and for holding the small amount of moisture that is present so that other plants can use it.

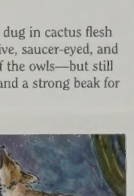
Plants of the Sonoran Desert

Saguaro Cactus. One of the largest cacti anywhere, the saguaro grows up to 12 meters tall. Early in its life, it needs the shade of other vegetation to survive. The saguaro cactus has a fluted appearance, allowing it to expand or contract like an accordion as it absorbs and stores moisture or becomes desiccated.

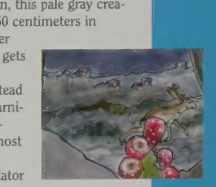


Teddy Bear Cholla Cactus. This cactus is pretty but treacherous. The dense covering of golden spines makes this cactus attractive, but these spines are sharply barbed and the joints will readily come off and become embedded in whatever brushes by them. It can grow to a height of 1.2 to 3.6 meters.

Engelmann's Prickly Pear Cactus. A common cactus of the Southwest and one of the most massive, the Engelmann's prickly pear cactus forms large, trunkless mounds up to 1.5 meters tall and many meters across. Individual pads can be 30 centimeters long. Its spines are white and downward-pointing. This cactus bears yellow flowers that are followed by bright red fruit.



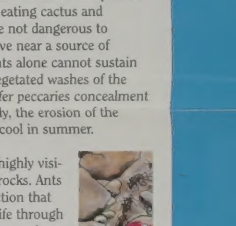
Barrel Cactus. A fat, barrel-shaped cactus with stout, hooked spines, the barrel cactus can grow up to 2.4 meters tall but is usually only 1.2 to 1.5 meters in height. Barrel cacti have radial spines surrounding a central spine. They are late bloomers, flowering in August or September. Barrel cacti have orange-red (and occasionally yellow) flowers that are followed by bright yellow fruit that is eaten by many animals. Several parts of the barrel cactus are used to make candy, resulting in the destruction of many stands of this cactus.



Saguaro Flower Cluster. This flower cluster is perched on top of an arm of the cactus. Saguaros begin to flower at 50 years of age. The flowers bloom in May, opening toward evening, staying open the next day, and then closing again for good. A few weeks later, the green fruits ripen and burst open, revealing a bright red, edible pulp.

Saguaro Cactus Trunk.

Ocotillo. A cactuslike tree, but not a cactus, the ocotillo blooms regardless of weather conditions over the previous winter and actually may bloom without leafing out in a particularly dry spring. The flower clusters of the ocotillo are tubular and scarlet red.



Traces of Prehistoric Peoples

1891 photograph of Casa Grande

Several prehistoric cultures occupied the Sonoran Desert after the Clovis people. People we call the Hohokam lived in the Salt, Gila, and Santa Cruz River basins of south-central Arizona from about 2,000 years ago to the beginning of the fifteenth century. The Hohokam are noted for the extensive network of canals they built to irrigate their fields of corn, beans, and squash. Archaeologists have found the remains of over 1,100 kilometers of Hohokam irrigation canals in the Phoenix Basin. Irrigation helped the Hohokam maintain a highly complex and sophisticated culture. They built large mounds in their villages; made beautiful textiles, shell jewelry, and pottery; and traded with groups as far away as the California coast, the Great Plains, the Rocky Mountains, and Mesoamerica. By the time Europeans arrived in the late seventeenth Century, the Hohokam culture seemed to have vanished, but many people believe the present-day Piman tribes of southern Arizona are the descendants of the ancient Hohokam.

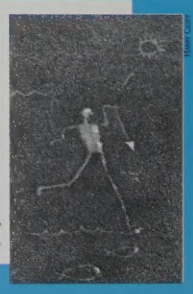
Among the most fascinating of evidence left by prehistoric inhabitants of the Sonoran Desert are petroglyphs or rock carvings. Petroglyphs are the result of chipping, pecking, rubbing, drilling, or scratching of a rock surface. Petroglyphs are often found on rock surfaces coated with "desert varnish" of iron- and manganese-oxides and other minerals. Such petroglyphs can be seen in contrast to the background rock because they have been formed by the removal of surface patina. In some instances, the exposed surface has had sufficient time and the conditions have been right for repatination to occur.

Painted Rock petroglyphs

Evidence suggests that one purpose of rock art—perhaps the principal purpose or function—was religious, having to do with sacred ceremony. Record-keeping, decoration, and doodling also seem to have been purposes.

The term *intaglio* (in-tal-yo) is taken from a printmaking process. Intaglios are usually engraved or incised on desert pavement terraces. These terraces are created by a complex process of water and wind. Rock materials were transported by ancient rivers and streams, then deposited in graded layers of coarse cobbles, gravels, and finer materials. Thousands of years of erosional forces eventually remove the finer materials, leaving a coarse, densely packed, level desert pavement behind. These cobbles and gravels are then slowly covered with layers of ferro-manganese deposits and colonies of microscopic organisms. Through the years, the stones develop a glossy patina that appears black from a distance. To create an intaglio, the large rocks are moved away and the small cobbles are scraped back to expose the lighter soils underneath, thus creating an image.

There is no absolute or conclusive way to date intaglios. Archaeologists' estimates of intaglio ages range from 10,000 years ago to the present. Intaglios can be ruined unintentionally by someone unaware of their existence or, more frequently, by vandals intentionally driving over the figures, senselessly scarring or obliterating them forever.



"Fisherman" intaglio

FOR THE CLASSROOM

Who Lives Here?

One of the greatest threats to plants and animals today is habitat depletion. Discuss some of the human activities that are changing the desert (need for more homes, increased roads, increased demand for recreation, desire to make the desert like another habitat by introducing exotic species). Have students research descriptions, accounts, and photographs of their local area as it was seen by early pioneers and explorers. Compare and contrast the area today with how it was in the past. What native plants and animals have become threatened, endangered, or extinct? What exotic plants and animals now live in this area? Locate natural springs and other natural water sources. Are these water sources still accessible to wildlife? What actions can students take to protect plants and animals near their homes?

Join the Club

Divide students into four groups. Assign each group to one of the following "clubs," each representing a particular plant adaptation for coping with the heat.

J. Scovil

The minerals of the Sonoran Desert are very important to the economy of Arizona as well as the United States. In 1995, the value of nonfuel production in Arizona, almost entirely from the Sonoran Desert, was about $3 billion, the highest in the nation. Production of copper from copper-bearing minerals of Arizona's Sonoran Desert accounts for about 60 percent of the nation's copper output. The Sonoran Desert has examples of minerals-such as wulfenite (beautiful reddish-orange crystals), the gemstone peridot, malachite, and azurite-which are prized by both amateur and professional collectors.

The blue color of this sample of malachite and azurite is characteristic of copper-bearing minerals. This specimen is from the Czar Shaft Mine in Bisbee, Arizona.

Suntan Lotion Lovers: Many plants limit the amount of moisture they can lose through evaporation by covering their leaves or pads with a waxy coating. This works much the same as suntan lotion or sunscreen in protecting us from "drying out" in the sun.

White Shirt Specials: Since light colors work to reflect the sun's rays, some plants "wear" light colors to keep cool and, in doing so, retain more moisture. Many desert plants have white leaves or hairy surfaces that work just as a white shirt to reflect the sun's rays.

Make Your Own Shade Club: If a plant is kept cool, it will lose less water through evaporation. Many plants are able to keep themselves somewhat cooler than the surrounding air temperature by "making their own shade." Spines on cacti and leaves on trees create shade for those plants.

Canteen Kids: Some plants are able to store large amounts of water in their thick leaves or stems. Members of this group are called *succulents*. Cacti are a good example of succulents. After water is taken up by the roots, it is then chemically changed by the cactus into a mucilaginous substance that does not evaporate as quickly as the watery sap found in large-leafed plants. This moisture is stored in the stem.

Ask each group to conduct research to identify desert plants that belong to their "club." On a bulletin board, have students display pictures of the plants in their club, together with descriptions about their special adaptations.

Creature Feature

Introduce students to the term *riparian zone*. This is an area that includes not only the water, but also the vegetation associated with the water. Many animals living in this area could not survive without the special conditions that the riparian zone provides. Riparian areas often provide different and more abundant vegetation than surrounding areas, a higher percentage of shade trees for nesting or shelter, higher humidity, and more diverse plant and animal life. Riparian areas are easily affected by natural and human-made changes.

Have students work in small groups to design a creature adapted to living in a riparian area. While they are designing the creature, have them consider the following questions:

- How are its feet adapted to the environment?
- What kind of body covering does it have that makes it well suited for living in an aquatic area (scales, feathers, shell)?
- Where are its eyes? How can it see above and below?
- How does it move (swim, fly, carried on current)?
- What does it eat? How is its mouth adapted to this kind of food?
- What kind of limbs does it have (arms, legs, flippers, gills, wings, tail)?
- What special adaptations does it have for surviving in a desert region (surviving flash floods, drought)?

Have students share their creatures with the class, discussing ways each animal has adapted to an aquatic habitat.

Extension: Talk about threats to riparian habitats. How would this creature adapt to these and other human-made changes? Would this creature disappear or would it adapt? What could be done to help protect this animal and still satisfy our water needs?

Planning a Conservation Community

Ideally, communities would not intrude on the desert's beauty to accommodate expanding growth and development. In some cases, however, communities "boxed in" by water or other features may have limited choices. In these cases, planning is critical to minimize impacts to the natural environment.

Have students work in teams to create a map of a "desert community" that demonstrates the importance of protecting the desert's fragile resources. Ask students to brainstorm a list of the facilities, resources, and services that their community would have. Consider the following questions:

- How do people get the food they need?
- Where do they live?

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FOR THE CLASSROOM

- How do they get around?
- Where do they go to work, to learn, to play?
- What public services are provided (police, fire, hospitals)?
- What provisions have been made to conserve water and energy resources; to protect air, water, and soil quality; and to preserve and protect natural areas?

After students have completed their maps, have them present them to the class and explain the special conservation features they have included.

About the Authors

Gary Stumpf is the lead archaeologist with the Bureau of Land Management (BLM) in Arizona. Richard Brook, also a BLM archaeologist, is actively involved with the BLM's heritage and environmental education programs. Mary Tisdale is the national coordinator for the BLM's environmental education and volunteer programs.

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For More Information

The Arizona-Sonora Desert Museum, 2021 N. Kinney Road, Tucson, AZ 85743; (520) 883-1380. Offers educational programs for children and outstanding exhibits.

Saguaro National Monument, 2700 N. Kinney Road, Tucson, AZ 85743; (520) 883-6366. Visitor center provides information about the Sonoran Desert and local history and prehistory. Also offers educational programs.

The Tucson Botanical Gardens, 2150 N. Alvernon Way, Tucson, AZ 85712; (520) 326-9686. Offers educational programs for schools, families, and children.

The Desert Botanical Gardens, 1201 N. Galvin Parkway, Phoenix, AZ; (602) 941-1217. In addition to flora exhibits, the gardens have an outdoor exhibit of a Piman rancheria, showing Native American uses of Sonoran Desert plants.

Casa Grande Ruins National Monument, P.O. Box 518, Coolidge, AZ 85228; (520) 723-3172. This Hohokam village site dating from A.D. 900–1450 includes a four-story adobe structure that may have been used for astronomical observations.

Heard Museum, 22 E. Monte Vista Road, Phoenix, AZ 85004; (602) 252-8840. Provides information on the aboriginal people who lived in the Sonoran Desert. Offers many educational programs through its Education and Public Programs Division.

Web66: A K–12 World Wide Web Project, http://web66.coled.umn.edu/schools.html. Offers listings of schools all over the United States and the world. Locate schools in the Sonoran Desert Region for possible school pen-pals.

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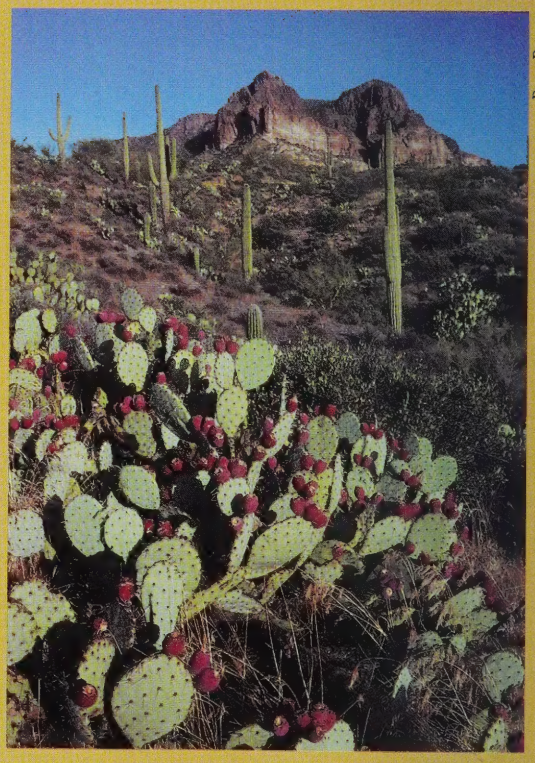

DIANE DROBKA

A Sonoran landscape with prickly pear and saguaro cactus against a mountain backdrop.